Chapter Sixty-four

QUANTITY COMPUTATIONS

BUREAU OF DESIGN AND ENVIRONMENT MANUAL

Chapter Sixty-four
QUANTITY COMPUTATIONS

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QUANTITY COMPUTATIONS

In addition to preparing clear and concise plans, as described in Chapter 63, the designer needs to compile an accurate summary of the project quantities. This information leads directly to the Engineer's Estimate, which combines the computed quantities of work and the estimated unit bid prices. An accurate summary of quantities is critical to prospective contractors interested in submitting a bid on the project. Chapter 64 presents guidelines on calculating quantities for highway construction projects.

64-1 GENERAL

64-1.01 Guidelines for Preparing Quantity Computations

When preparing quantity computations, the designer should consider the following guidelines:

1. Specifications. Cross check all items against the *IDOT Standard Specifications for Road and Bridge Construction* and the Supplemental Specifications to ensure that the appropriate pay items, methods of measurement, and bases of payment are used. If an item is not covered in the *IDOT Standard Specifications* or Supplemental Specifications (i.e., those having an asterisk in the *IDOT Coded Pay Items*), a special provision, plan note or detail must be included in the contract documents to cover the item.

2. Pay Item Code Number. Every pay item has a unique number assigned to it for data processing. This code number is located in the *IDOT Coded Pay Items.* Section 63-4.04 describes the Department coding procedures, description titles, and units of measurement for pay items. Only the official name and description should be used in the contract documents, special provisions, and summary of quantities. Do not include "dummy" code numbers in the plans.

3. Rounding. The quantity of any item provided in the plans should check exactly with the figure on the computation sheets. Indicate any rounding of the raw estimated figures on the computation sheets. Unless stated otherwise, no rounding of the calculations should be done until the value is incorporated into the summary of quantities sheet.

4. Significant Digits. When calculating quantities, carefully consider the implied correspondence between the accuracy of the data and the given number of digits.

5. Multiple Estimates. Some projects will require two or more estimates for work performed under various funding arrangements, construction and safety work types, and area location. Section 63-4.04 describes the various breakdown categories for quantity computations.

6. Cost Estimate. Only use the total values from the summary of quantities sheets to develop the cost estimate. Show all items described in the plans that will be included in the cost estimate on the plan sheets. Chapter 65 provides Department criteria for preparing construction cost estimates. These quantities are used to determine the final Engineer's Estimate.

7. Estimating Forms/Computation Worksheets. Blank copies of the estimating forms and computation worksheets are available from BDE.

64-1.02 Computer Estimates

For most projects, the computer can be used to develop some of the quantity estimates. For small projects, it may be more efficient to manually calculate the quantities for all elements, including earthwork. Each software package used by the Department (e.g., GEOPAK) uses different procedures for determining how and which quantities can be estimated. The designer should give special consideration to how the plans are prepared on the computer (e.g., cell names, levels, processing procedures) to allow the software to determine the quantities.

64-1.03 Computation Records

In preparing the project quantities, prepare a separate computation sheet for each item used on the project. Combine these sheets and bind them with a cover sheet. The preparer will sign or initial and date each sheet. The checker will also be required to sign or initial and date each sheet. Number the sheets and indicate the total number of pages on each sheet (i.e., sheet x of y). Place the code number and pay item on the top of each sheet. Arrange the sheets in code number order (i.e., numerically and then alphabetically).

Check all values obtained through computations or use of standardized tables, preferably on an independent basis. For those pay items where agreements may be reached to make payment on the basis of planned quantities, an independent check should be performed and noted. Note the resolution of any differences between original and check computations. Where computations are performed by computer, an independent check is not required. However, make spot checks of the input and review the computation output sheet for obvious mistakes. Also, sign and date the computer output similarly to hand computation sheets.

Retain the quantity computations within the project file.

64-1.04 Units of Measurement

Estimate the quantities for all contract bid items using the terms and units of measurement presented in the *IDOT Standard Specifications* and the *IDOT Coded Pay Items*. Show the values determined from the computations on the summary of quantities sheet, and elsewhere in the plans. Figure 64-1.A illustrates typical rounding criteria that should be used on the summary of quantities sheet and in the plans. Note that certain elements are rounded based on standard manufacturer sizes.

Item	Measured Unit	Degree of Accuracy
A		
ADJUSTING SANITARY SEWERS	FOOT	1
ADJUSTING WATER SERVICE LINES	FOOT	1
AGGREGATE	TON	1
AGGREGATE (PRIME COAT)	TON	1
AGGREGATE BASE COURSE	CUBIC YARD, TON, SQUARE YARD	1, 1, 1
AGGREGATE BASE REPAIR	TON	1
AGGREGATE SHOULDERS	TON, CUBIC YARD, SQUARE YARD	1, 1, 1
AGGREGATE SURFACE COURSE	SQUARE YARD, CUBIC YARD, TON	1, 1, 1
AGRICULTURAL GROUND LIMESTONE	TON	0.1
ALUMINUM END SECTIONS	EACH	1
ALUMINUM RAILING	FOOT	1
AREA REFLECTIVE CRACK CONTROL TREATMENT	SQUARE YARD	0.5
ASPHALT MODIFIER	GALLON	1
B		
BACKSLOPE DRAINS TYPES 1, 2, AND 3	FOOT	1
BARE COPPER WIRE	FOOT	1
BASE COURSE WIDENING	SQUARE YARD	1
BITUMINOUS BASE COURSE	SQUARE YARD	1
BITUMINOUS CONCRETE BINDER/SURFACE COURSE	TON, SQUARE YARD	1, 1
BITUMINOUS CONCRETE PAVEMENT (FULL-DEPTH)	SQUARE YARD	1
BITUMINOUS MATERIAL APPLIED	GALLON, TON	1, 0.1
BITUMINOUS MATERIALS	GALLON, TON	1, 0.1
BITUMINOUS SHOULDER CURB	FOOT	1
BITUMINOUS SHOULDERS	SQUARE YARD, TON	1, 1
BITUMINOUS SURFACE COAT	SQUARE YARD	1
BITUMINOUS SURFACE REMOVAL	SQUARE YARD	1
BLOTTER AGGREGATE	TON	1
BORROW EXCAVATION	CUBIC YARD	5
BOX CULVERT END SECTIONS	EACH	1
BRIDGE APPROACH PAVEMENT	SQUARE YARD	1
BRIDGE DECK GROOVING	SQUARE YARD	1

QUANTITY ROUNDING CRITERIA — US CUSTOMARY

Figure 64-1.A

Item	Measured Unit	Degree of Accuracy
BRIDGE SEAT SEALER	SQUARE YARD	1
BRIDGE WASHING	EACH	1
C		
CABLE ROAD GUARD REMOVAL	FOOT	1
CABLE ROAD GUARD, SINGLE STRAND	FOOT	1
CALCIUM CHLORIDE APPLIED	TON	0.1
CAST IRON SOIL PIPE	FOOT	1
CAST-IN-PLACE PILE EXTENSIONS	FOOT	0.5
CATCH BASINS	EACH	1
CATCH BASINS TO BE ADJUSTED/RECONSTRUCTED	EACH	1
CEMENT	HUNDRED WEIGHT	1
CHAIN LINK FENCE	FOOT	1
CHAIN LINK GATES	EACH	1
CHANNEL EXCAVATION	CUBIC YARD	1
CLASS A, B, C, D PATCHES	SQUARE YARD	1
CLASS MS CONCRETE	CUBIC YARD	0.1
CLASS SI CONCRETE	CUBIC YARD	0.1
COFFERDAM EXCAVATION	CUBIC YARD	1
COFFERDAMS	EACH	1
COMBINATION CONCRETE CURB AND GUTTER	FOOT	0.5
COMBINATION CURB AND GUTTER REMOVAL	FOOT	1
CONCRETE BARRIER	FOOT	1
CONCRETE BLOCK RIPRAP	SQUARE YARD	1
CONCRETE BOX CULVERTS	CUBIC YARD	0.1
CONCRETE CURB/GUTTER	FOOT	0.5
CONCRETE GLARE SCREEN	FOOT	0.5
CONCRETE HANDRAIL	CUBIC YARD	0.1
CONCRETE HEADWALL REMOVAL	EACH	1
CONCRETE HEADWALLS	CUBIC YARD	0.1
CONCRETE MEDIAN	SQUARE FOOT	1
CONCRETE REMOVAL	CUBIC YARD	0.1

QUANTITY ROUNDING CRITERIA — US CUSTOMARY

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
CONCRETE STRUCTURES	CUBIC YARD	0.1
CONCRETE SUPERSTRUCTURE	CUBIC YARD	0.1
CONCRETE THRUST BLOCKS	EACH	1
CONDUIT	FOOT	1
CONSTRUCTING TEST STRIP	EACH	1
CONTINUOUSLY REINFORCED PORTLAND CEMENT CONCRETE PAVEMENT	SQUARE YARD	1
CONTROL INSTALLATION	EACH	1
CORRUGATED STRUCTURAL PLATE ARCHES, PIPE ARCHES, PIPE CULVERTS	FOOT	1
COVER COAT AGGREGATE	TON	1
CRACK FILLING	POUND	0.5
CRACK ROUTING (PAVEMENT)	FOOT	1
CURB REMOVAL	FOOT	1
D		
DELINEATORS	EACH	1
DOMESTIC METER VAULTS TO BE MOVED	EACH	1
DOMESTIC WATER SERVICES BOXES TO BE MOVED	EACH	1
DRAINAGE STRUCTURES	EACH	1
DRIVEWAY PAVEMENT REMOVAL	SQUARE YARD	1
DRIVING AND FILLING SHELLS	FOOT	1
DRIVING PILES	FOOT	1
E		
EARTH EXCAVATION	CUBIC YARD	5
EARTH EXCAVATION (WIDENING)	CUBIC YARD	5
EARTH EXCAVATION FOR EROSION CONTROL	CUBIC YARD	5
ELASTOMERIC BEARING ASSEMBLY	EACH	1
ELECTRIC CABLE IN TRENCH	FOOT	1
ELECTRICAL CONDUCTORS IN CONDUIT	FOOT	1
END SECTIONS	EACH	1
ENGINEER'S FIELD LABORATORY	CALENDAR MONTH	1
ENGINEER'S FIELD OFFICE	CALENDAR MONTH	1
EPOXY CRACK SEALING	FOOT	1
EPOXY MORTAR REPAIR	GALLON	1

QUANTITY ROUNDING CRITERIA — US CUSTOMARY

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
ERECTING STRUCTURAL STEEL	LUMP SUM	1
EROSION CONTROL BLANKET	SQUARE YARD	1
EXCAVATING AND GRADING EXISTING SHOULDER	UNIT	1
EXPANSION BOLTS	EACH	1
EXPANSION TIE ANCHORS	EACH	1
EXPLORATION TRENCH	FOOT	1
F		
FABRIC FORMED CONCRETE REVETMENT MATS	SQUARE YARD	1
FENCE (EROSION CONTROL)	FOOT	1
FIBER MAT	SQUARE YARD	1
FIELD TILE JUNCTION VAULTS	EACH	1
FILLING CATCH BASINS, INLETS, MANHOLES	EACH	1
FILTER FABRIC FOR USE WITH RIPRAP	SQUARE YARD	1
FIRE HYDRANTS TO BE MOVED	EACH	1
FLAP GATE	EACH	1
FLOOR DRAINS	EACH	1
FRAMES AND GRATES	EACH	1
FRAMES AND GRATES TO BE ADJUSTED	EACH	1
FRENCH DRAINS	CUBIC YARD	1
FURNISHED EXCAVATION	CUBIC YARD	5
FURNISHING AND ERECTING DRAINAGE MARKERS	EACH	1
FURNISHING AND ERECTING PRECAST, PRESTRESSED CONCRETE I - BEAMS	FOOT	0.5
FURNISHING AND ERECTING STRUCTURAL STEEL	LUMP SUM, POUND	1, 10
FURNISHING AND PLACING COMPOST	SQUARE YARD	1
FURNISHING AND PLACING TOPSOIL	SQUARE YARD	1
FURNISHING CONCRETE PILES	FOOT	1
FURNISHING STRUCTURAL STEEL	LUMP SUM	1
G		
GABIONS	CUBIC YARD	1
GEOCOMPOSITE WALL DRAIN	SQUARE YARD	1
GEOTECHNICAL FABRIC	SQUARE YARD	1
GLARE SCREEN BLADES	EACH	1

QUANTITY ROUNDING CRITERIA — US CUSTOMARY

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
GRANULAR EMBANKMENT, SPECIAL	CUBIC YARD, TON	5, 1
GRATES	EACH	1
GRATING FOR CONCRETE FLARED END SECTION	EACH	1
GUARDRAIL REMOVAL	FOOT	1
GUTTER REMOVAL	FOOT	1
H		
HARDWARE	POUND	10
HEAT SCARIFYING	SQUARE YARD	1
I		
INCIDENTAL BITUMINOUS SURFACING	TON	1
INLET BOX, STANDARDS *XXXX*	EACH	1
INLETS	EACH	1
INLETS TO BE ADJUSTED/RECONSTRUCTED	EACH	1
INSERTION CULVERT LINER	FOOT	1
J		
JOINT OR CRACK FILLING	POUND	10
JOINT OR CRACK ROUTING	FOOT	1
L		
LEVELING BINDER (HAND METHOD)	TON	0.1
LEVELING BINDER (MACHINE METHOD)	TON	1
LIGHT POLE ALUMINUM	EACH	1
LIGHT POLE FOUNDATION	EACH	1
LIGHT TOWER	EACH	1
LIGHT TOWER FOUNDATION	FOOT	0.5
LIME	TON	0.1
LOCATING UNDERGROUND CABLE	FOOT	1
LUG SYSTEM COMPLETE	EACH	1
LUMINAIRE, SODIUM VAPOR	EACH	1
M		
MANHOLES	EACH	1
MANHOLES TO BE ADJUSTED/RECONSTRUCTED	EACH	1
MASONRY REMOVAL	CUBIC YARD	0.1
MEDIAN INLETS	EACH	1

QUANTITY ROUNDING CRITERIA — US CUSTOMARY

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
MEDIAN REMOVAL	SQUARE YARD	1
MEMBRANE WATERPROOFING	SQUARE YARD	0.5
METAL SHOES	EACH	1
MICRO-SURFACING	SQUARE YARD	1
MIXTURE FOR CRACKS, JOINTS, AND FLANGEWAYS	TON	0.1
MOWING	ACRE	0.25
MULCH METHOD 1, 2, 3	ACRE	0.25
N		
NAME PLATES	EACH	1
NEOPRENE EXPANSION JOINT	FOOT	0.5
P		
PAINTING STEEL RAILING	FOOT	1
PAINTING STRUCTURAL STEEL	LUMP SUM	1
PAVED DITCH	FOOT	1
PAVED DITCH REMOVAL	FOOT	1
PAVED SHOULDER REMOVAL	SQUARE YARD	1
PAVEMENT PATCHING	SQUARE YARD	1
PAVEMENT REINFORCEMENT	SQUARE YARD	1
PAVEMENT REMOVAL	SQUARE YARD	1
PC CONCRETE BRIDGE APPROACH SHOULDER PAVEMENT	SQUARE YARD	1
PCC BASE COURSE	SQUARE YARD	1
PCC BASE COURSE WIDENING	SQUARE YARD	1
PERENNIAL PLANTS	UNIT	1
PERIMETER EROSION BARRIER	FOOT	1
PILE TEST LOADING	EACH	1
PIPE CULVERT REMOVAL	FOOT	1
PIPE CULVERTS	FOOT	1
PIPE DRAINS	FOOT	1
PIPE HANDRAIL	FOOT	0.5
PIPE UNDERDRAINS	FOOT	1
POROUS GRANULAR BACKFILL	CUBIC YARD	1
POROUS GRANULAR EMBANKMENT	CUBIC YARD, TON	1, 1

QUANTITY ROUNDING CRITERIA — US CUSTOMARY

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
PORTLAND CEMENT CONCRETE DRIVEWAY PAVEMENT	SQUARE YARD	1
PORTLAND CEMENT CONCRETE PAVEMENT	SQUARE YARD	1
PORTLAND CEMENT CONCRETE SHOULDERS	SQUARE YARD	1
PORTLAND CEMENT CONCRETE SIDEWALK	SQUARE FOOT	0.5
PORTLAND CEMENT CONCRETE SURFACE REMOVAL	SQUARE YARD	0.5
PRECAST CONCRETE BOX CULVERTS	FOOT	0.5
PRECAST CONCRETE BRIDGE SLAB	SQUARE FOOT	1
PRECAST REINFORCED CONCRETE FLARED END SECTIONS	EACH	1
PRECAST, PRESTRESSED CONCRETE DECK BEAMS	SQUARE FOOT	1
PREFORMED JOINT SEAL	FOOT	0.5
PREPARATION OF BASE	SQUARE YARD	1
PROCESSING LIME MODIFIED SOILS	SQUARE YARD	1
PROTECTIVE COAT	SQUARE YARD	1
R		
REINFORCEMENT BARS	POUND	10
RELOCATE TEMPORARY CONCRETE BARRIER	FOOT	1
REMOVAL OF EXISTING STRUCTURES	EACH	1
REMOVAL OF EXISTING SUPERSTRUCTURES	EACH	1
REMOVE AND REERECT STEEL PLATE BEAM GUARDRAIL	FOOT	12.5
RIP RAP	SQUARE YARD	1
ROCK EXCAVATION	CUBIC YARD	1
ROCK EXCAVATION FOR STRUCTURES	CUBIC YARD	1
S		
SAND BACKFILL	CUBIC YARD	1
SEAL COAT AGGREGATE	TON, CUBIC YARD	1, 1
SEAL COAT CONCRETE	CUBIC YARD	0.1
SEEDING, INTERSEEDING	ACRE	0.25
SEEDLINGS	UNIT	0.1
SHAPING AND GRADING ROADWAY	UNIT	1
SHRUBS	EACH	1
SIDEWALK REMOVAL	SQUARE FOOT	1
SLOPE WALL	SQUARE YARD	1

QUANTITY ROUNDING CRITERIA — US CUSTOMARY

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
SODDING	SQUARE YARD	1
STABILIZED SUBBASE	SQUARE YARD	1
STEEL PLATE BEAM GUARDRAIL	FOOT	12.5
STEEL RAILING	FOOT	1
STORM SEWERS	FOOT	1
STRIP REFLECTIVE CRACK CONTROL TREATMENT	FOOT	1
STRUCTURE EXCAVATION	CUBIC YARD	1
STUD SHEAR CONNECTORS	EACH	1
SUBBASE GRANULAR MATERIAL	SQUARE YARD, CUBIC YARD, TON	1, 1, 1
SUPPLEMENTAL WATERING	UNIT	0.1
T		
TEMPORARY BRIDGE COMPLETE	EACH	1
TEMPORARY CONCRETE BARRIER	FOOT	12.5
TEMPORARY CONCRETE BARRIER TERMINAL SECTION	EACH	1
TEMPORARY PAVEMENT MARKING	FOOT	1
TEMPORARY PAVEMENT MARKING LETTERS AND SYMBOLS	SQUARE FOOT	1
TRAFFIC CONTROL AND PROTECTION STANDARD *XXXX*	LUMP SUM, EACH	1, 1
TRANSVERSE TERMINAL JOINT COMPLETE	EACH	1
TREE PRUNING	EACH	1
TREE REMOVAL	UNIT, ACRE	1, 0.25
TREES	EACH	1
U		
UNDERGROUND STORAGE TANK REMOVAL	EACH	1
UNIT DUCT	FOOT	1
V		
VINES	EACH	1
W		
WATER	UNIT	0.1
WATER MAIN	FOOT	1
WATER SERVICE LINE	FOOT	1
WATERPROOFING MEMBRANE SYSTEM	SQUARE FOOT	1
WIDE FLANGE BEAM TERMINAL JOINT COMPLETE	EACH	1

QUANTITY ROUNDING CRITERIA — US CUSTOMARY

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
A		
ADJUSTING SANITARY SEWERS	METER	1
ADJUSTING WATER SERVICE LINES	METER	1
AGGREGATE	TON	1
AGGREGATE (PRIME COAT)	TON	1
AGGREGATE BASE COURSE	CUBIC METER, TON, SQUARE METER	1, 1, 1
AGGREGATE BASE REPAIR	TON	1
AGGREGATE SHOULDERS	TON, CUBIC METER, SQUARE METER	1, 1, 1
AGGREGATE SURFACE COURSE	SQUARE METER, CUBIC METER, TON	1, 1, 1
AGRICULTURAL GROUND LIMESTONE	TON	0.1
ALUMINUM END SECTIONS	EACH	1
ALUMINUM RAILING	METER	0.5
AREA REFLECTIVE CRACK CONTROL TREATMENT	SQUARE METER	0.5
ASPHALT MODIFIER	LITER	1
B		
BACKSLOPE DRAINS TYPES 1, 2 AND 3	METER	0.5
BARE COPPER WIRE	METER	1
BASE COURSE WIDENING	SQUARE METER	1
BITUMINOUS BASE COURSE	SQUARE METER	1
BITUMINOUS CONCRETE BINDER/SURFACE COURSE	TON, SQUARE METER	1, 1
BITUMINOUS CONCRETE PAVEMENT (FULL-DEPTH)	SQUARE METER	1
BITUMINOUS MATERIAL APPLIED	LITER, TON	1, 1
BITUMINOUS MATERIALS	LITER, TON	1, 0.1
BITUMINOUS SHOULDER CURB	METER	1
BITUMINOUS SHOULDERS	SQUARE METER, TON	1, 1
BITUMINOUS SURFACE COAT	SQUARE METER	1
BITUMINOUS SURFACE REMOVAL	SQUARE METER	1
BLOTTER AGGREGATE	TON	1
BORROW EXCAVATION	CUBIC METER	5
BOX CULVERT END SECTIONS	EACH	1
BRIDGE APPROACH PAVEMENT	SQUARE METER	1
BRIDGE DECK GROOVING	SQUARE METER	1

QUANTITY ROUNDING CRITERIA — METRIC

Figure 64-1.A

Item	Measured Unit	Degree of Accuracy
BRIDGE SEAT SEALER	SQUARE METER	1
BRIDGE WASHING	EACH	1
C		
CABLE ROAD GUARD REMOVAL	METER	1
CABLE ROAD GUARD, SINGLE STRAND	METER	1
CALCIUM CHLORIDE APPLIED	TON	0.1
CAST IRON SOIL PIPE	METER	0.5
CAST-IN-PLACE PILE EXTENSIONS	METER	0.1
CATCH BASINS	EACH	1
CATCH BASINS TO BE ADJUSTED/RECONSTRUCTED	EACH	1
CEMENT	HUNDRED WEIGHT	1
CHAIN LINK FENCE	METER	0.5
CHAIN LINK GATES	EACH	1
CHANNEL EXCAVATION	CUBIC METER	5
CLASS A, B, C, D PATCHES	SQUARE METER	1
CLASS MS CONCRETE	CUBIC METER	0.1
CLASS SI CONCRETE	CUBIC METER	0.1
COFFERDAM EXCAVATION	CUBIC METER	1
COFFERDAMS	EACH	1
COMBINATION CONCRETE CURB AND GUTTER	METER	0.1
COMBINATION CURB AND GUTTER REMOVAL	METER	1
CONCRETE BARRIER	METER	1
CONCRETE BLOCK RIPRAP	SQUARE METER	1
CONCRETE BOX CULVERTS	CUBIC METER	0.1
CONCRETE CURB/GUTTER	METER	0.1
CONCRETE GLARE SCREEN	METER	0.1
CONCRETE HANDRAIL	CUBIC METER	0.1
CONCRETE HEADWALL REMOVAL	EACH	1
CONCRETE HEADWALLS	CUBIC METER	0.1
CONCRETE MEDIAN	SQUARE METER	1
CONCRETE REMOVAL	CUBIC METER	0.1
CONCRETE STRUCTURES	CUBIC METER	0.1

QUANTITY ROUNDING CRITERIA — METRIC

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
CONCRETE SUPERSTRUCTURE	CUBIC METER	0.1
CONCRETE THRUST BLOCKS	EACH	1
CONDUIT	METER	0.5
CONSTRUCTING TEST STRIP	EACH	1
CONTINUOUSLY REINFORCED PORTLAND CEMENT CONCRETE PAVEMENT	SQUARE METER	1
CONTROL INSTALLATION	EACH	1
CORRUGATED STRUCTURAL PLATE ARCHES, PIPE ARCHES, PIPE CULVERTS	METER	1
COVER COAT AGGREGATE	TON	1
CRACK FILLING	KILOGRAM	0.1
CRACK ROUTING (PAVEMENT)	METER	0.5
CURB REMOVAL	METER	1
D		
DELINEATORS	EACH	1
DOMESTIC METER VAULTS TO BE MOVED	EACH	1
DOMESTIC WATER SERVICES BOXES TO BE MOVED	EACH	1
DRAINAGE STRUCTURES	EACH	1
DRIVEWAY PAVEMENT REMOVAL	SQUARE METER	1
DRIVING AND FILLING SHELLS	METER	0.5
DRIVING PILES	METER	0.5
E		
EARTH EXCAVATION	CUBIC METER	5
EARTH EXCAVATION (WIDENING)	CUBIC METER	5
EARTH EXCAVATION FOR EROSION CONTROL	CUBIC METER	5
ELASTOMERIC BEARING ASSEMBLY	EACH	1
ELECTRIC CABLE IN TRENCH	METER	1
ELECTRICAL CONDUCTORS IN CONDUIT	METER	1
END SECTIONS	EACH	1
ENGINEER'S FIELD LABORATORY	CALENDAR MONTH	1
ENGINEER'S FIELD OFFICE	CALENDAR MONTH	1
EPOXY CRACK SEALING	METER	1
EPOXY MORTAR REPAIR	LITER	1
ERECTING STRUCTURAL STEEL	LUMP SUM	1

QUANTITY ROUNDING CRITERIA — METRIC

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
EROSION CONTROL BLANKET	SQUARE METER	1
EXCAVATING AND GRADING EXISTING SHOULDER	UNIT	1
EXPANSION BOLTS	EACH	1
EXPANSION TIE ANCHORS	EACH	1
EXPLORATION TRENCH	METER	1
F		
FABRIC FORMED CONCRETE REVETMENT MATS	SQUARE METER	1
FENCE (EROSION CONTROL)	METER	1
FIBER MAT	SQUARE METER	1
FIELD TILE JUNCTION VAULTS	EACH	1
FILLING CATCH BASINS, INLETS, MANHOLES	EACH	1
FILTER FABRIC FOR USE WITH RIPRAP	SQUARE METER	1
FIRE HYDRANTS TO BE MOVED	EACH	1
FLAP GATE	EACH	1
FLOOR DRAINS	EACH	1
FRAMES AND GRATES	EACH	1
FRAMES AND GRATES TO BE ADJUSTED	EACH	1
FRENCH DRAINS	CUBIC METER	1
FURNISHED EXCAVATION	CUBIC METER	5
FURNISHING AND ERECTING DRAINAGE MARKERS	EACH	1
FURNISHING AND ERECTING PRECAST, PRESTRESSED CONCRETE I - BEAMS	METER	0.1
FURNISHING AND ERECTING STRUCTURAL STEEL	LUMP SUM, KILOGRAM	1, 10
FURNISHING AND PLACING COMPOST	SQUARE METER	1
FURNISHING AND PLACING TOPSOIL	SQUARE METER	1
FURNISHING CONCRETE PILES	METER	0.5
FURNISHING STRUCTURAL STEEL	LUMP SUM	1
G		
GABIONS	CUBIC METER	1
GEOCOMPOSITE WALL DRAIN	SQUARE METER	1
GEOTECHNICAL FABRIC	SQUARE METER	0.5
GLARE SCREEN BLADES	EACH	1
GRANULAR EMBANKMENT, SPECIAL	CUBIC METER, TON	5, 1

QUANTITY ROUNDING CRITERIA — METRIC

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
GRATES	EACH	1
GRATING FOR CONCRETE FLARED END SECTION	EACH	1
GUARDRAIL REMOVAL	METER	1
GUTTER REMOVAL	METER	1
H		
HARDWARE	KILOGRAM	10
HEAT SCARIFYING	SQUARE METER	1
I		
INCIDENTAL BITUMINOUS SURFACING	TON	1
INLET BOX, STANDARDS *XXXX*	EACH	1
INLETS	EACH	1
INLETS TO BE ADJUSTED/RECONSTRUCTED	EACH	1
INSERTION CULVERT LINER	METER	0.5
J		
JOINT OR CRACK FILLING	KILOGRAM	10
JOINT OR CRACK ROUTING	METER	1
L		
LEVELING BINDER (HAND METHOD)	TON	0.1
LEVELING BINDER (MACHINE METHOD)	TON	1
LIGHT POLE ALUMINUM	EACH	1
LIGHT POLE FOUNDATION	EACH	1
LIGHT TOWER	EACH	1
LIGHT TOWER FOUNDATION	METER	0.1
LIME	TON	0.1
LOCATING UNDERGROUND CABLE	METER	1
LUG SYSTEM COMPLETE	EACH	1
LUMINAIRE, SODIUM VAPOR	EACH	1
M		
MANHOLES	EACH	1
MANHOLES TO BE ADJUSTED/RECONSTRUCTED	EACH	1
MASONRY REMOVAL	CUBIC METER	0.1
MEDIAN INLETS	EACH	1
MEDIAN REMOVAL	SQUARE METER	1

QUANTITY ROUNDING CRITERIA — METRIC

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
MEMBRANE WATERPROOFING	SQUARE METER	0.5
METAL SHOES	EACH	1
MICRO-SURFACING	SQUARE METER	1
MIXTURE FOR CRACKS, JOINTS, AND FLANGEWAYS	TON	0.1
MOWING	HECTARE	0.1
MULCH METHOD 1, 2, 3	HECTARE	0.1
N		
NAME PLATES	EACH	1
NEOPRENE EXPANSION JOINT	METER	0.1
P		
PAINTING STEEL RAILING	METER	1
PAINTING STRUCTURAL STEEL	LUMP SUM	1
PAVED DITCH	METER	1
PAVED DITCH REMOVAL	METER	1
PAVED SHOULDER REMOVAL	SQUARE METER	1
PAVEMENT PATCHING	SQUARE METER	1
PAVEMENT REINFORCEMENT	SQUARE METER	1
PAVEMENT REMOVAL	SQUARE METER	1
PC CONCRETE BRIDGE APPROACH SHOULDER PAVEMENT	SQUARE METER	1
PCC BASE COURSE	SQUARE METER	1
PCC BASE COURSE WIDENING	SQUARE METER	1
PERENNIAL PLANTS	UNIT	1
PERIMETER EROSION BARRIER	METER	1
PILE TEST LOADING	EACH	1
PIPE CULVERT REMOVAL	METER	1
PIPE CULVERTS	METER	0.5
PIPE DRAINS	METER	0.5
PIPE HANDRAIL	METER	0.1
PIPE UNDERDRAINS	METER	0.5
POROUS GRANULAR BACKFILL	CUBIC METER	1
POROUS GRANULAR EMBANKMENT	CUBIC METER, TON	1, 1
PORTLAND CEMENT CONCRETE DRIVEWAY PAVEMENT	SQUARE METER	1

QUANTITY ROUNDING CRITERIA — METRIC

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
PORTLAND CEMENT CONCRETE PAVEMENT	SQUARE METER	1
PORTLAND CEMENT CONCRETE SHOULDERS	SQUARE METER	1
PORTLAND CEMENT CONCRETE SIDEWALK	SQUARE METER	0.5
PORTLAND CEMENT CONCRETE SURFACE REMOVAL	SQUARE METER	0.5
PRECAST CONCRETE BOX CULVERTS	METER	0.1
PRECAST CONCRETE BRIDGE SLAB	SQUARE METER	1
PRECAST REINFORCED CONCRETE FLARED END SECTIONS	EACH	1
PRECAST, PRESTRESSED CONCRETE DECK BEAMS	SQUARE METER	0.5
PREFORMED JOINT SEAL	METER	0.1
PREPARATION OF BASE	SQUARE METER	1
PROCESSING LIME MODIFIED SOILS	SQUARE METER	1
PROTECTIVE COAT	SQUARE METER	1
R		
REINFORCEMENT BARS	KILOGRAM	10
RELOCATE TEMPORARY CONCRETE BARRIER	METER	1
REMOVAL OF EXISTING STRUCTURES	EACH	1
REMOVAL OF EXISTING SUPERSTRUCTURES	EACH	1
REMOVE AND REERECT STEEL PLATE BEAM GUARDRAIL	METER	3.81
RIP RAP	SQUARE METER	1
ROCK EXCAVATION	CUBIC METER	1
ROCK EXCAVATION FOR STRUCTURES	CUBIC METER	1
S		
SAND BACKFILL	CUBIC METER	1
SEAL COAT AGGREGATE	TON, CUBIC METER	1, 1
SEAL COAT CONCRETE	CUBIC METER	0.1
SEEDING, INTERSEEDING	HECTARE	0.1
SEEDLINGS	UNIT	0.1
SHAPING AND GRADING ROADWAY	UNIT	1
SHRUBS	EACH	1
SIDEWALK REMOVAL	SQUARE METER	1
SLOPE WALL	SQUARE METER	1
SODDING	SQUARE METER	1

QUANTITY ROUNDING CRITERIA — METRIC

Figure 64-1.A
(Continued)

Item	Measured Unit	Degree of Accuracy
STABILIZED SUBBASE	SQUARE METER	1
STEEL PLATE BEAM GUARDRAIL	METER	3.81
STEEL RAILING	METER	0.5
STORM SEWERS	METER	0.5
STRIP REFLECTIVE CRACK CONTROL TREATMENT	METER	1
STRUCTURE EXCAVATION	CUBIC METER	1
STUD SHEAR CONNECTORS	EACH	1
SUBBASE GRANULAR MATERIAL	SQUARE METER, CUBIC METER, TON	1, 1, 1
SUPPLEMENTAL WATERING	UNIT	0.1
T		
TEMPORARY BRIDGE COMPLETE	EACH	1
TEMPORARY CONCRETE BARRIER	METER	3.81
TEMPORARY CONCRETE BARRIER TERMINAL SECTION	EACH	1
TEMPORARY PAVEMENT MARKING	METER	1
TEMPORARY PAVEMENT MARKING LETTERS AND SYMBOLS	SQUARE METER	1
TRAFFIC CONTROL AND PROTECTION STANDARD *XXXX*	LUMP SUM, EACH	1, 1
TRANSVERSE TERMINAL JOINT COMPLETE	EACH	1
TREE PRUNING	EACH	1
TREE REMOVAL	UNIT, HECTARE	1, 0.1
TREES	EACH	1
U		
UNDERGROUND STORAGE TANK REMOVAL	EACH	1
UNIT DUCT	METER	1
V		
VINES	EACH	1
W		
WATER	UNIT	0.1
WATER MAIN	METER	0.5
WATER SERVICE LINE	METER	0.5
WATERPROOFING MEMBRANE SYSTEM	SQUARE METER	0.5
WIDE FLANGE BEAM TERMINAL JOINT COMPLETE	EACH	1

QUANTITY ROUNDING CRITERIA — METRIC

Figure 64-1.A
(Continued)

64-1.05 Non-Defined Work

64-1.05(a) Lump-Sum Items

Only use lump sum bid items where the scope of work for the item is clearly defined, and the amount of work has a minimal chance of changing during construction. The *IDOT Standard Specifications* defines which quantities may be estimated as lump sum. Wherever practical, list the quantities for the separate items that will be included within the lump sum item. The list should note that the separate "quantities are for estimating purposes only." Where there is a significant chance of quantity changes, the work must be bid by the unit and not lump sum. Where lump sum items are used, the total quantity for the project will always equal one.

64-1.05(b) Items Included in Other Work

No item should be shown as incidental to another pay item or the contract. If any item will be included as part of another item, it must be addressed by the specifications or with a special provision. The designer should only include an item of work in another pay item where the scope of work for both is clearly defined and the probability of the quantity of either item changing is minimal. In general, minimize the use of items included in other pay items. It is impossible for bidders, or the Department, to prepare an estimate for a project that contains incidental items for which quantities or the scope of work are indeterminable.

In general, use the applicable pay item for those items that are normally covered in the *IDOT Standard Specifications*. Where the quantities or scope of work items are indeterminate at the time of bidding, these items should be paid for on a force account basis as described in the *IDOT Standard Specifications*.

64-1.06 Federal Participation in Stockpiling of Salvage Materials

The Federal government participates in the cost of salvaging and stockpiling materials, which cannot be reused in the project. This does not apply to material salvaged from Bituminous Surface Removal or Texturing Existing Pavement, which becomes the property of the contractor for future recycling. Stockpile the material either on the project limits or at a State-owned storage site a reasonable distance off the project limits if necessary to prevent a potential roadside safety problem. The amount of participation will be limited to the following:

- If the material can be used on other Federal-aid routes, participation may be obtained for stockpiling the material.
- If the material is to be retained by the contractor, participation may be obtained for salvaging the material provided the special provisions indicate that the salvage value is to be reflected in the contractor's bid price.
- If the material can be used on non-Federal-aid routes, Federal participation for stockpiling will ordinarily be limited to the dollar amount established by an alternate bid item for contractor disposal.

- If the material has no use, participation will be allowed for the disposal of the material as specified in Article 202.03 of the *Standard Specifications*.

64-2 EARTHWORK COMPUTATIONS

64-2.01 Computer Computations

Earthwork computations for most projects can be determined using the computer and special design software packages (e.g., GEOPAK). Earthwork quantities for small projects, entrances, side roads, ditches, and additional grading features may need to be calculated manually (see Section 64-2.02). For the computer to calculate the mainline earthwork quantities, the following information is typically required:

1. horizontal and vertical roadway alignment;
2. typical sections;
3. terrain data;
4. shrinkage factor;
5. cut and fill slope rates; and
6. identification of sections not to be included (e.g., bridge sections).

The computer provides a listing of the quantities for each station. Include these quantities on the cross sections as described in Section 63-4.16.

64-2.02 Manual Computations

For small projects and to calculate special features on larger projects (e.g., entrances, ditches), it may be necessary to calculate the earthwork quantities manually. Figure 64-2.A provides a sample computation sheet that may be used to develop these quantities. A spreadsheet program may be used in place of these computation sheets. The following steps and examples from Figure 64-2.A illustrate how to use the computation sheet:

1. Station. In rural areas, cross sections are typically plotted and calculated at 100 ft (25 m) intervals and urban areas at 50 ft (10 m) intervals. The intervals shown in Figure 64-2.A are at 50 ft.

2. Grade. Indicate the grade of the profile grade line. Also, indicate if there is a vertical curve and the length of the vertical curve. Figure 64-2.A shows a 500 ft crest vertical curve.

3. Tangent Elevation. This is the grade along the tangent between two VPI's, exclusive of the vertical curve correction. In the example, the tangent elevations are 465.00 ft and 466.00 ft at Stations 4 + 00 and 4 + 50, respectively.

4. Vertical Curve Correction. This is the elevation correction required from the tangent elevation for the vertical curve. Values in this column only will be noted if there is a vertical curve. Chapter 33 illustrates how to calculate the vertical curve corrections. For Station 4 + 00, the correction is 0.12 ft, and for Station 4 + 50, 0.50 ft.

EARTHWORK COMPUTATIONS

Computed By: _____ Date: _____ Route Example

Checked By: _____ Date: _____ Section _____

Shrinkage Factor 15% County/City _____

(1) Sta. No.	(2) % Grade	(3) Tangent Elev. (ft)	(4) Vert. Curve Corr. (ft)	(5) Grade Elev. (ft)	(6) End Area (ft^2) Cut	(6) End Area (ft^2) Fill	(7) Sum of End Area (ft^2) Cut	(7) Sum of End Area (ft^2) Fill	(8) Distance (ft)	(9) Section Volumes (yd^3) Cut	(9) Section Volumes (yd^3) Fill
1 + 50	+2%	460.00	—	460.00	0	0					
							4	430	50	4	398
2 + 00	+2%	461.00	—	461.00	4	430					
							14	1080	50	13	1000
2 + 50	+2%	462.00	—	462.00	10	650					
							60	700	50	56	648
3 + 00	+2%	463.00	—	463.00	50	50					
							1350	70	50	1250	65
3 + 50		464.00	VPC	464.00	1300	20					
							3000	30	50	2778	28
4 + 00		465.00	0.12	464.88	1700	10					
							3450	10	50	3194	9
4 + 50		466.00	0.50	465.50	1750	0					
							3650	0	50	3380	0
5 + 00		467.00	1.12	465.88	1900	0					
							3900	0	50	3611	0
5 + 50		468.00	2.00	466.00	2000	0					
							4500	0	50	4167	0
6 + 00		469.00	3.12	465.88	2500	0					
							5000	0	50	4630	0
6 + 50		467.50	2.00	465.50	2500	0					
							4700	0	50	4352	0
7 + 00		466.00	1.12	464.88	2200	0					
							3900	5	50	3611	5
7 + 50		464.50	0.50	464.00	1700	5					
							2550	35	50	2361	32
8 + 00		463.00	0.12	462.88	850	30					
							1350	110	50	1250	102
8 + 50		461.50	VPT	461.50	500	80					
							700	180	50	648	167
9 + 00	-3%	460.00	—	460.00	200	100					
							210	145	50	194	134
9 + 50	-3%	458.50	—	458.50	10	45					
							10	55	50	9	51
10 + 00	-3%	457.00	—	457.00	0	10					
							0	10	50	0	9
10 + 50	-3%	455.50	—	455.50	0	0					
	(*)	(*)	(*)	(*)							
									Total Section Volumes	35,508	2648
									Shrinkage Factor	—	1.15
									Adjusted Volume	35,508	3045

500 ft Vertical Curve

(*) These columns are optional.

SAMPLE COMPUTATION SHEET

Figure 64-2.A

5. Grade Elevation. This is the actual grade of the profile grade line. For tangent sections, this column is the same elevation as shown in the tangent elevation column. For crest vertical curves, this elevation is determined by subtracting the vertical curve correction from the tangent elevation. For sag vertical curves, this elevation is determined by adding the vertical curve correction to the tangent elevation. For Station 4 + 00, the grade elevation is (465.00 - 0.12 = 464.88 ft) and for Station 4 + 50, (466.00 – 0.50) = 465.50 ft.

6. End Areas. The end areas used to compute the quantities are defined by the ground lines and typical section template (see Figure 64-2.B). After the cross sections have been plotted, determine the areas of cut and fill for each cross section using a planimeter. Include the borrow excavation, waste of unsuitable soils, undercut, rock excavation, trench excavation, and any special excavation or embankment on the section. If topsoil is used on the section, compute the quantity of topsoil. Add the undercut in the cut section to the earth excavation and deduct the topsoil in fill from the embankment quantity. Record the cut and fill areas for each cross section in the "END AREA" columns of the Computation Sheet. Ensure that intermediate cross sections (e.g., culvert location, entrances) are not used for an end section. For the example, the cut end areas for Stations 4 + 00 and 4 + 50 are 1700 ft^2 and 1750 ft^2, respectively. The fill end areas are 10 ft^2 and 0 ft^2, respectively.

7. Sum of End Areas. The "SUM OF END AREAS" columns are the sum of adjacent cross-section areas for the cut and fill columns. Note that the line in the figure is offset between the two end areas. This line indicates the two areas to be added together. For the example, the sum of cut areas is 3450 ft^2 and sum of fill areas is 10 ft^2.

8. Distance. This is the distance between the cross-section interval selected in Comment 1. For the example, this is 50 ft.

9. Section Volumes. Volumes for excavation (cut) and embankment (fill) are determined using the average-end-area formula:

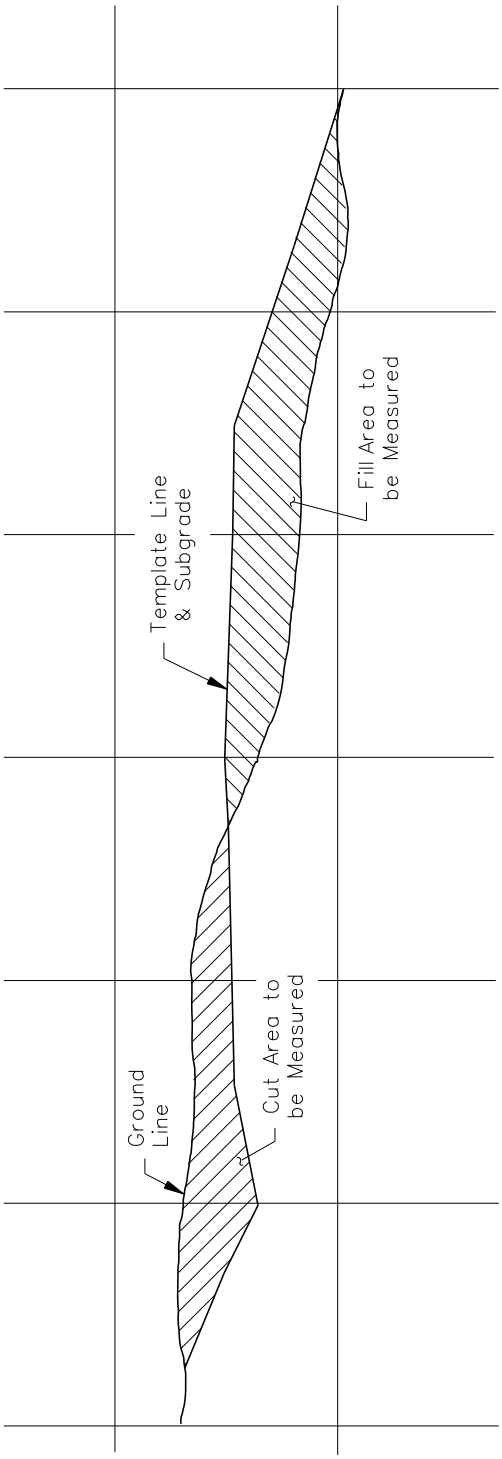
$$V = \left(\frac{A_1 + A_2}{2(27)}\right)(D) \qquad \text{(US Customary) Equation 64-2.1}$$

$$V = \left(\frac{A_1 + A_2}{2}\right)(D) \qquad \text{(Metric) Equation 64-2.1}$$

where: V = volume, yd^3 (m^3)

$A_1 + A_2$ = sum of cut or fill end areas of adjacent sections (from the "Sum of End Areas"), ft^2 (m^2)

D = distance between sections, ft (m)



END AREA TEMPLATE

Figure 64-2.B

These values are rounded to the nearest yd^3 (m^3) and recorded in the appropriate cut and fill "SEC. VOLUMES" columns on the Computation Sheet.

For the example, the cut and fill volumes are:

Cut: $$V = \left(\frac{1700 + 1750}{2(27)}\right)(50) = 3194 \text{ yd}^3$$

Fill: $$V = \left(\frac{10 + 0}{2(27)}\right)(50) = 9 \text{ yd}^3$$

10. Total Section Volumes. This is the sum of the section volumes for both the cut and fill columns. For the example, these are 35,508 yd^3 for cut sections and 2648 yd^3 for fill sections.

11. Shrinkage Factor. The total section volumes for fill section must be adjusted by the appropriate shrinkage factor. Section 64-2.03 discusses how to determine the appropriate shrinkage factor. For this example, the shrinkage factor was determined to be 15%. Note for earth fills, the factor is only shown in the fill column.

12. Adjusted Volume. This value is determined by multiplying the "TOTAL SECTION VOLUME" by the appropriate "SHRINKAGE FACTOR." For cut sections, the volume is 35,508 yd^3. For fill sections, the 2648 yd^3 is multiplied by 1.15 to obtain the "ADJUSTED VOLUME" (2648 x 1.15 = 3045 cubic yards).

64-2.03 Shrink and Swell Factors

Embankment fill quantities calculated manually or by the computer must be adjusted by the appropriate shrinkage factor to account for the compaction of material, loss from hauling, subsidence of the existing ground caused by the overburden, erosion, and clearing operation. The factors used in the calculations depend on the soil type, quantity to be moved, and engineering judgment. Sand and gravel have smaller shrinkage factors than clay and silt. For rock excavation, it may be necessary to apply an expansion or swell factor. Generally, the shrinkage factor will only be applied to the total fill area (see Section 64-2.02) unless highly variable materials are encountered along the alignment requiring different numerical values.

The use of more than one factor is often necessary to describe the characteristics of the material. The District Geotechnical Engineer will provide guidance in choosing the applicable factor(s) to be used in the calculations. The designer may need to adjust the shrinkage factor to account for the smaller quantities.

64-2.04 Earthwork Considerations

64-2.04(a) Excavation Quantities

The following procedures establish design guidelines for use of the earthwork pay items:

1. Earth and Rock Excavation. This work consists of excavation and transportation of suitable excavated material to embankment locations throughout the limits of the contract or the excavation, transportation, and disposal of excavated material. This work does not include excavation for structures or channel excavation.

   Calculate quantities in the normal manner according to Section 64-2.

   If the earth or rock excavation is to be used on the project in an embankment, the suitability and/or stability of the excavated material must be examined. Show the amount of suitable excavated material to be used in embankments in the Earthwork Schedule. The pay item is “Earth Excavation” or “Rock Excavation.” If a portion or all of the excavated material is determined to be unsuitable or unstable, calculate the quantity and list it as “Removal and Disposal of Unsuitable Material.”

   When possible, a shrinkage factor should be determined for the suitable excavation to be used as embankment. The shrinkage factor will determine the final volume of the excavated material once it is compacted within the embankment. This quantity is then used to determine the amount of material either to be wasted or to be hauled in from off-site. Contact the District Materials Engineer concerning the determination of a shrinkage factor. When a shrinkage factor is determined, show the factor in the plans. If no shrinkage factor is determined, assume a shrinkage factor of 25%.

   If topsoil is to be excavated and used on the project, include this quantity as “Topsoil Excavation and Placement,” but do not include this quantity in the earth excavation quantity. Cross sections should show the different cut quantities.

2. Borrow and Furnished Excavation. Borrow and furnished excavation consists of excavating suitable materials obtained from borrow locations furnished by the contractor and transporting the materials to various locations throughout the limits of the contract.

   The only difference between borrow excavation and furnished excavation is the method of measurement as described below:

   a. Borrow Excavation. Borrow excavation is measured in its original position by taking cross sections of the borrow site before the work is started and again after it has been completed. The volume in cubic yards (cubic meters) of material will be computed by the method of average end areas. When possible, also determine the shrinkage factor of the borrow excavation. The shrinkage factor will determine the plan quantity of material to be excavated from the borrow site, which is the pay quantity, that will provide the required volume once it is compacted in the embankment. The District Materials Engineer should be contacted regarding the determination of a shrinkage factor. When a shrinkage

factor is determined it should be shown on the plans. If no shrinkage factor is determined, assume a shrinkage factor of 25%.

b. Furnished Excavation. Furnished excavation will be determined either by an agreement to plan quantity or by measurement in its final place. For measurement in place, compute the volume of the compacted material in cubic yards (cubic meters) using the average end areas method and then subtract the final pay quantity of earth excavation, rock excavation and other excavation suitable to be used as embankment, adjusted by a shrinkage factor of 25% or as shown on the plans, as discussed above. Also, deduct the excavation quantities included in the cost of other items.

The use of borrow excavation or furnished excavation will be at the designer's discretion; however, the designer should consult with the District Materials Engineer and District Construction Engineer. In determining which pay item to use, consider the following:

- Do not use borrow excavation and furnished excavation on the same project; use one or the other.
- Furnished excavation should be used:
  - + on projects where a small amount of borrow material is required (<50,000 yd^3 (40,000 m^3));
  - + on bridge projects, minor realignments, and/or 3R type improvements;
  - + on projects in urbanized areas where borrow may come from many sources;
  - + where no suitable borrow locations are apparent; or
  - + where use of commercial borrow sites or multiple borrow sites are anticipated.
- Borrow excavation should be used:
  - + on projects where a significant amount of borrow material is required (>50,000 yd^3 (40,000 m^3)); or
  - + where a borrow site may be readily available.

3. Embankment. This work consists of the construction of embankments by depositing, placing, and compacting earth, stone, gravel, or other materials of acceptable quality above the natural ground or other surface. The materials incorporated are from earth excavation, rock excavation, borrow excavation, furnished excavation, or other sources as mentioned in the contract documents.

Embankment will not be paid for directly, but is considered to be included in the various items of excavation, and their construction included in the unit prices of these items.

4. Topsoil and Compost. This work consists of furnishing, excavating, and placing topsoil, special types of topsoil or compost/topsoil blend.

   The use of topsoil on projects is paid for either as "Topsoil Excavation and Placement" or as "Topsoil Furnish and Place." The designer will decide which pay item(s) to use and should consult with the District Landscape Architect, District Materials Engineer, and District Construction Engineer for assistance. Topsoil excavation and placement involves the use of topsoil obtained from within the project limits. Topsoil furnish and place requires the contractor to obtain topsoil from an off-site location. The use of topsoil within the project limits is encouraged and recommended. In determining contract quantities, on-site material should be used first and, if additional quantities are required, the amount of off-site material should be calculated. Consequently, on some projects both pay items may be used.

   The quantity of topsoil excavation and placement is not included in the earth excavation quantity.

5. Earthwork Schedule. Earthwork schedules are shown on all plans involving earthwork pay items. The schedule should show:

   - cuts and fills;
   - earth and rock excavation quantities;
   - removal and disposal of unsuitable material quantities;
   - borrow or furnished excavation quality (Note that borrow excavation is calculated in the uncompacted state so a shrinkage factor must be assumed to arrive at this quantity from the known fill required. Furnished excavation is calculated in its final place (i.e., compacted state));
   - shrinkage factors for earth excavation and borrow excavation; and
   - topsoil excavation and placement, topsoil furnish and place, and/or compost furnish and place quantities.

6. Equations. Consider the following when calculating excavation quantities:

   a. $$\text{Shrinkage Factor (SF)} = \frac{\text{bank volume} - \text{compacted volume}}{\text{bank volume}}$$

   $$= 1 - \frac{\text{compacted volume}}{\text{bank volume}}$$

Where the bank volume is material as it lies in its natural state.

Unless otherwise determined, assume SF = 0.25.

b. Suitable Excavation is defined to be all earth excavation, rock excavation, and all other on-site excavation that is suitable to be used as embankment for the project.

c. Use the following to determine the quantity of embankment that will result from the suitable excavation:

Excavation to be used as Embankment = Suitable Excavation X (1 – SF)

d. If the quantity of excavation to be used as embankment is less than the embankment quantity required, then use one of the following equations:

Furnished Excavation = Embankment – (Suitable Excavation X (1 – SF)

Borrow Excavation = (Embankment – (Suitable Excavation X (1 – SF))) / (1 – SF)

It is the designer's option on use of the borrow excavation or furnished excavation when off-site material is needed.

7. Examples.

Example 64-2.04(1)

Earthwork Schedule

1 Location	2 Earth Excavation	3 Earth Excavation Adjusted for Shrinkage	4 Embankment	5 Earthwork Balance Waste (+) or Shortage (-)
	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard
Sta. 100+00 to 105+00	500	375	100	+275
Sta. 105+00 to 110+00	400	300	100	+200
Sta. 110+00 to 115+00	500	375	200	+175
Side Road A	200	150	300	-150
Total	1600	1200	700	+500

Columns 1, 2, & 4 Location and quantities from cross sections:

Cut = Earth Excavation Fill = Embankment

Column 3 Quantity of earth excavation (cut) adjusted for a shrinkage factor of 25%.

Column 5 Earthwork required:

(-) = Quantity of Fill or Embankment needed (Furnished or Borrow Excavation).
(+) = Quantity to be wasted.

Because the earth excavation quantity is greater than embankment needed the only pay item is for "Earth Excavation," no pay item for "Borrow or Furnished Excavation" is needed.

Pay Item:

EARTH EXCAVATION 1600 cubic yards

Example 64-2.04(2)

Earthwork Schedule

1 Location	2 Earth Excavation	3 Earth Excavation Adjusted for Shrinkage	4 Embankment	5 Earthwork Balance Waste (+) or Shortage (-)
	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard
Sta. 320+00 to 325+00	100	75	275	-200
Sta. 325+00 to 330+00	200	150	125	+25
Sta. 330+00 to 335+00	150	112.5	300	-187.5
Side Road X	50	37.5	250	-212.5
Total	500	375	950	-575

Columns 1, 2, & 4 Location and quantities from cross sections:

Cut = Earth Excavation Fill = Embankment

Column 3 Quantity of earth excavation (cut) adjusted for a shrinkage factor of 25%.

Column 5 Earthwork required:

(-) = Quantity of Fill or Embankment needed (Furnished or Borrow Excavation).
(+) = Quantity to be wasted.

Because the earth excavation quantity is not great enough to account for all embankment (fill) needed, additional earth is required from off-site either as borrow or furnished excavation.

Example 64-2.04(3)

Earthwork Schedule

1 Location	2 Earth Excavation	3 Rock Excavation	4 Unsuitable or Unstable Material	5 Excavation to be used in Embankment Adjusted for Shrinkage	6 Embankment	7 Earthwork Balance Waste (+) or Shortage (-)	8 Topsoil Excavation and Placement	9 Topsoil Furnish and Place
	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard	Square Yard
Sta. 410+00 to 430+00	3,000		1,000	1,600	10,000	-8,400	600	
Sta. 430+00 to 450+00	2,000	500		2,100	8,000	-5,900	200	300
Sta. 450+00 to 470+00	5,000			4,000	2,000	+2,000	200	400
Frontage Road	1,000			800	5,000	-4,200	300	
Total	11,000	500	1,000	8,500	25,000	-16,500	1,300	700

Shrinkage Factors: Earth Excavation: 20%
Rock Excavation: 0%
Borrow Excavation: 30%

Column 1 – Location from plans.

Column 2 – Cut quantities from cross sections, this does not include topsoil excavation.

Column 3 – Quantities from cross sections.

Column 4 – Cut material that is determined to be either unstable or unsuitable for use in embankment.

Column 5 – Earth and rock excavation quantities that are to be used as fill material in embankment. Includes deduction for unsuitable material. Earth excavation shrinkage factor was determined to be 20%. Rock excavation shrinkage factor was determined to be 0%.

Column 6 – Quantities from cross sections.

Column 7 – Off-site material needed or material to waste.

Column 8 – Quantities from cross sections, these quantities are not included in earth excavation or embankment.

Column 9 – Quantities required from off-site to complete project, quantities are not included in borrow or furnished excavation.

Furnished excavation is measured in its final (compacted) state. Borrow excavation is measured at the borrow site and, therefore, the borrow quantity must allow for shrinkage (assumed 25%). Borrow = 575 yd^3 / (1 – 0.25) = 766.67 yd^3.

Pay Items:

EARTH EXCAVATION	-	500 cubic yards
FURNISHED EXCAVATION	-	575 cubic yards

or

EARTH EXCAVATION	-	500 cubic yards
BORROW EXCAVATION	-	767 cubic yard

On projects in which cut material is paid for with multiple pay items (e.g., Earth Excavation and Rock Excavation), calculate the total quantity of cut material to determine the quantity of off-site material required for embankment. Each item may have a different shrinkage factor.

On projects in which topsoil is to be paid for, the topsoil quantities are not included in any other pay items (e.g., earth excavation, furnished excavation). First, calculate the total quantity of topsoil needed. Next, calculate the amount of topsoil available within the project limits. If not enough topsoil is available on the project, then the additional amount will be obtained from off-site and paid for as "Topsoil Furnish and Place." A shrinkage factor may be used for topsoil, but is not usually required.

Borrow excavation quantity is 16,500/(1-0.30) = 23,571 cubic yards. If furnish excavation were used the quantity would be 16,500 cubic yards.

Pay Items:

EARTH EXCAVATION	-	10,000 cubic yards
ROCK EXCAVATION	-	500 cubic yards
REMOVAL AND DISPOSAL OF UNSUITABLE MATERIAL	-	1,000 cubic yards
BORROW EXCAVATION	-	23,571 cubic yards
TOPSOIL EXCAVATION AND PLACEMENT	-	1,300 cubic yards
TOPSOIL FURNISH AND PLACE	-	700 square yards

64-2.04(b) Earthwork Quantities for Separate Grading and Paving Contracts

On grading and paving contracts, the paving contractor may have the problem of either wasting substantial quantities of excess excavation or obtaining borrow to construct the subgrade. Often the plans do not provide the contractor with the proper quantities to adequately estimate the project. To ensure that sufficient quantities are provided, the designer should consider the following:

1. Grading Contracts. For grading contracts, show the grading cross sections parallel to the ultimate pavement and shoulder structure. Occasionally, special conditions may dictate a different grading cross section. For these situations, provide accurate earthwork quantities to construct the final paving cross section in the paving plans.

2. Graded Paving Contracts. For paving contracts on pregraded sections, do not include the earthwork in the cost of paving or use "token" quantities to establish unit prices. determine the earthwork quantities according to one of the following conditions:

    a. When a grading contract will be completed several months before the advertising of the paving contract, develop new cross sections to establish accurate earthwork quantities.

    b. When the paving contract will be advertised prior to the completion of the grading contract, accurate earthwork quantities cannot be determined for bidding purposes. For these situations, include the pay item "Shaping and Grading Roadway."

64-2.04(c) Bridge Embankment Quantities

For determining bridge embankment quantities, the Bureau of Bridges and Structures will only show on the general plan and elevation sheet of the bridge plans the limits of the minimum embankment that must be constructed prior to the construction of the abutments. The road designer is responsible for determining the quantities for the embankment cones and including these quantities in the total earthwork for the project.

The bridge plans will present any pipe culverts under these embankment cones. However, the road designer determines the pipe culvert length and any quantities.

64-2.05 Landscaping

When determining landscaping quantities, the designer should consider the following:

1. Seeding and Sodding. Calculate the area for seeding and sodding by measuring the distance along the slope and not horizontally.

2. Fertilizer Nutrients. To determine the quantity of fertilizer nutrients, multiply the area to be fertilized by the application rate. The designer should check with the District Landscape Architect to determine the proper application rate. Show the selected application rate in the plans, typically in the general notes.

3. Mulch. To determine the quantity of mulch, multiply the area to be mulched by the application rate obtained from the District Landscape Architect. Show the application rate in the plans, typically in the general notes.

64-2.06 Subgrade

Calculate the area of subgrade using the out-to-out width of the paved shoulders. To ensure a proper pavement foundation, add 6 in (150 mm) to each side. If the paved shoulders are bituminous, include an allowance for the 1V:1H slope of the bituminous material before adding the 6 in (150 mm) to each side.

For urban sections with curb and gutter, calculate the subgrade width using the out-to-out distance from the back of curb plus the 6 in (150 mm) extension.

64-2.07 Subbase

To determine the area of subbase under rigid pavements, include an additional 18 in (450 mm) on each side to the pavement width. Where curb and gutter is used with rigid pavements, the extra width will be the curb and gutter width.

64-3 PAVEMENT COMPUTATIONS

64-3.01 Bituminous

64-3.01(a) Bituminous Binder and Surface Course

Where bituminous binder and surface course pay items are in square yards (square meters), calculate the quantities using the top surface area. For binder course construction without curb and gutter, allow for the 1V:1H side slope of the surface course material before determining the width of the binder course. For binder course construction with curb and gutter on an improved subgrade, allow for the additional thickness required below the curb and gutter.

Where the pay item is in tons, provide an allowance for the extra width required due to the slope of the bituminous material. This allowance is not required for curb and gutter sections.

64-3.01(b) Bituminous Materials Applied

The designer should consult with the District Materials Engineer to determine the proper application rate of material for the type of project being constructed. This rate should be shown on the plans.

64-3.02 Pavement Rehabilitation

When determining quantities for pavement patching, conduct a field inspection immediately prior to the plan submission. Add a growth factor of 10% to 20% if the bids on the project will be received in late summer or fall and there is a likelihood that patching would not be completed until the following spring.

64-3.03 Shoulders/Curb and Gutter

64-3.03(a) Shoulders

Where the pay item is in square yards (square meters), use the top width of the shoulder to determine the area of shoulders.

64-3.03(b) Curb and Gutters

To determine the length of curb and gutters, measure the length along the gutter flow line. This length is measured across entrances and not around an entrance radius. The curbs in entrances should be included in the area of the entrance. At street returns, measure the curb around the radius of the return.

64-4 MISCELLANEOUS COMPUTATIONS

64-4.01 Bridges Deck Slab Repair Quantities

There may be a lag time between the time of inspection of the deck and the recording of the plan quantities and the start of actual construction. To reduce possible overruns on deck slab repair quantities, inspection of the deck should not occur more than four months prior to taking of bids for work. On projects on which bids are taken in late summer or fall, add a growth factor of 5% to 10% to the measured quantities to allow for the additional winter period between the inspection and the start of construction.

When a project is delayed and the deck(s) are subject to additional winter wear, make an update inspection prior to taking bids for the work. Conduct this updated inspection in the same manner as the initial inspection. The designer is responsible for keeping the records of the dates for all inspections.

Also, to reduce possible overruns, conduct a thorough and complete deck inspection. A detailed visual inspection of the underside of the deck is extremely critical. Time may be saved by not determining the corrosion potential and chloride content of the concrete.

The Department may secure outside consultants to conduct these inspections.

64-4.02 Trench Backfill

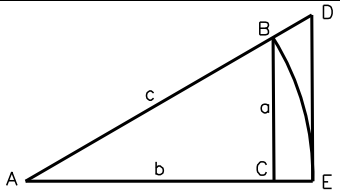
Calculate the trench backfill quantities using the trench backfill tables in the *IDOT Construction Manual*.

64-4.03 Aggregate

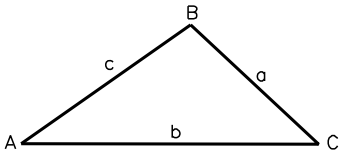
When calculating the quantity of aggregate required for temporary entrances, temporary lanes, etc., indicate the pay item in tons. Also, include additional quantities for maintenance during time the temporary facility is open to traffic.

64-5 MATHEMATICAL FORMULAS

This section presents mathematical formulas used by IDOT for various quantity determinations.



Right Triangle



Oblique Triangle

Right Triangles

$\sin A = \frac{a}{c} = \cos B$

$\cos A = \frac{b}{c} = \sin B$

$\tan A = \frac{a}{b} = \cot B$

$\sec A = \frac{c}{b} = \operatorname{cosec} B$

$\operatorname{cosec} A = \frac{c}{a} = \sec B$

$\cot A = \frac{b}{a} = \tan B$

$a = c \sin A = c \cos B = b \tan A = b \cot B = \sqrt{c^2 - b^2}$

$b = c \cos A = c \sin B = a \cot A = a \tan B = \sqrt{c^2 - a^2}$

$c = \frac{a}{\sin A} = \frac{a}{\cos B} = \frac{b}{\sin B} = \frac{b}{\cos A}$

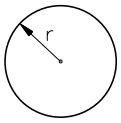
Oblique Triangles

Given	Sought	Formula
A, B, a	b, c	$b = \frac{a}{\sin A} \cdot \sin B$ $\quad c = \frac{a}{\sin A} \cdot \sin (A+B)$
A, a, b	B, c	$\sin B = \frac{\sin A}{a} \cdot b$ $\quad c = \frac{a \sin (A + \text{arc sin } (b \sin A / a))}{\sin A}$
C, a, b	$\frac{1}{2}(A + B)$ $\frac{1}{2}(A - B)$	$\frac{1}{2}(A+B) = 90° - \frac{1}{2} C$ $\text{Tan } \frac{1}{2} (A - B) = \frac{a - b}{a + b} \cdot \tan \frac{1}{2} (A+B)$
a, b, c	A	Given $s = \frac{1}{2}(a+b+c)$, then : $\sin \frac{1}{2} A = \sqrt{\frac{(s - b)(s - c)}{bc}}$ $\cos \frac{1}{2} A = \sqrt{\frac{s(s - a)}{bc}}$ $\tan \frac{1}{2} A = \sqrt{\frac{(s - b)(s - c)}{s(s - a)}}$ $\sin A = 2\frac{\sqrt{s(s - a)(s - b)(s - c)}}{bc}$
	Area	$\text{Area} = \sqrt{s(s - a)(s - b)(s - c)}$
c, a, b	Area	$\text{Area} = \frac{1}{2} ab \sin C$

Nomenclature

A = total surface area
d = distance
h = height
p = perimeter
r = radius
s = side (edge) length, arc length
V = volume
θ = vertex angle, in radians
ϕ = central angle, in radians

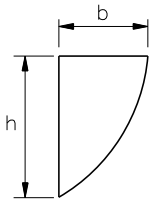
Circle



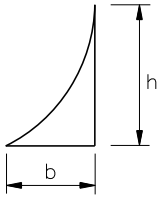
$p = 2\pi r$

$A = \pi r^2 = \frac{p^2}{4\pi}$

Parabola

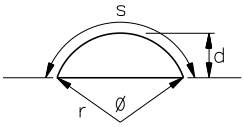


$A = \frac{2bh}{3}$



$A = \frac{1}{3}bh$

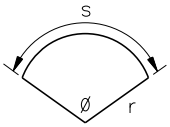
Circular Segment (1)



$A = \frac{1}{2}r^2(\phi - \sin\phi)$

$\phi = \frac{s}{r} = 2\left(\arccos\frac{r-d}{r}\right)$

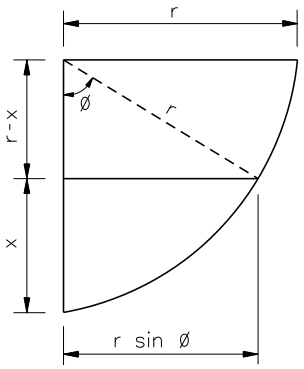
Circular Sector



$A = \frac{1}{2}\phi r^2 = \frac{1}{2}sr$

$\phi = \frac{s}{r}$

Circular Segment (2)



$\cos\phi = \frac{r-x}{r}$

Area of Circle Segment

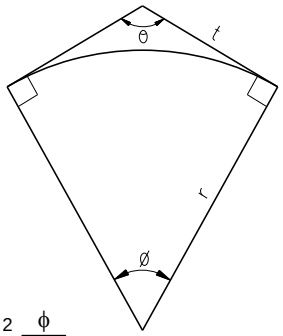
$\frac{\phi}{360°}\pi r^2$

Area of Triangle

$\frac{1}{2}(r - x)(r \sin\phi)$

External Area

Total Area - Area of Circle Segment = External Area



$t = \frac{r}{\tan\frac{\theta}{2}}$

$\phi = 180° - \theta$

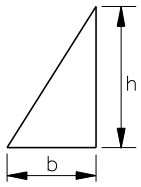
Total Area $= rt = \frac{r^2}{\tan\frac{\theta}{2}}$

Area of Circle Seg. $= \pi r^2 \frac{\phi}{360}$

Ext. Area $= r^2\left[\frac{1}{\tan\frac{\theta}{2}} - \pi\frac{\phi}{360}\right]$

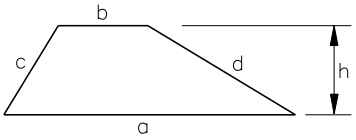
Number of Sides	Name of Polygon
3	triangle
4	rectangle
5	pentagon
6	hexagon
7	heptagon
8	octagon
9	nonagon
10	decagon

Triangle



$$A = \frac{1}{2} bh$$

Trapezoid

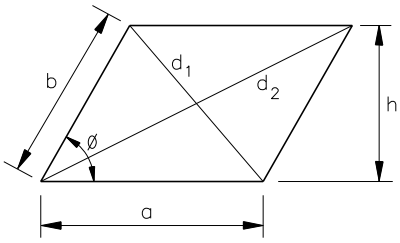


$$p = a + b + c + d$$

$$A = \frac{1}{2} h (a + b)$$

The trapezoid is isosceles if c = d.

Parallelogram



$$p = 2 (a + b)$$

$$d_1 = \sqrt{a^2 + b^2 - 2ab(\cos \phi)}$$

$$d_2 = \sqrt{a^2 + b^2 + 2ab(\cos \phi)}$$

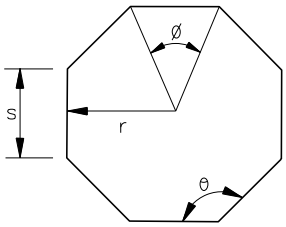
$$d_1^2 + d_2^2 = 2 (a^2 + b^2)$$

$$A = ah = ab(\sin \phi)$$

If a = b, the parallelogram is a rhombus.

Regular Polygon

(n equal sides)



$$\phi = \frac{2\pi}{n}$$

$$\theta = \frac{\pi (n - 2)}{n}$$

$$p = ns$$

$$s = 2r \left(\tan \left(\frac{\phi}{2} \right) \right)$$

$$A = \frac{1}{2} nsr$$